will say, remain to be dealt with in subsequent lectures of the course.

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Chemistry as Affecting the Profitableness of Industry[1]

In beginning the preparation of this paper I had thought of considering chemical industry as if it were distinct from other industries, but, as the subject developed, it became very apparent that no such distinct line could be drawn. Properly speaking, all industries must be considered as chemical. It is next to impossible to imagine the existence of an industry in which chemical reactions or considerations, either directly or indirectly, do not enter. It is possible that we could define chemical industry in a somewhat restricted sense, but such a definition would hardly be other than arbitrary. The lines of demarcation would be indistinct and shadowy. The only basis for such a definition would be the attitude of the popular mind. This attitude of mind has been steadily growing towards the recognition that chemistry is an important factor in every industry, and when, in any particular case, it becomes popularly recognized that chemistry is a factor in an industry, then that industry becomes a chemical industry. Ultimately, this popular recognition will extend to all industries and the rapidity of the growth of such recognition indicates that the time is not far distant when all industries will be generally and popularly recognized as chemical.

My plan had been to discuss the profitableness of chemical industry, but if we accept this conception that all industries are chemical, it would seem better that our discussion should be broadened so as to consider the general effect of chemistry upon the profitableness of industrial operations, using the words "industrial operations" as including all phases of the actual production of wealth.

Perhaps it would be well that I should make clear the conception that all industries are chemical in one or more phases. By way of illustration, let us consider the relation of chemistry to the production of power. I think we can show that there is a very close connection between chemistry and such production, and also that there is no industry which does not depend upon the consumption of power, and if this is the case, it becomes very evident that, from the power standpoint alone, all industries are chemical industries.

Our first impressions of power are those which we ourselves are conscious of exercising, and, in practise, the simplest form of power is man power as manifested in manual labor. It is not customary, perhaps, except from the humanitarian standpoint, to consider the chemical changes in the human body, converting food into work, as factors in industry. Nevertheless, they deserve serious consideration. It is being learned daily that properly fed employees are more efficient as workmen, and the study of food problems is surely a phase of the application of chemistry to industry. In some industries, the study of the food consumed by employees has a direct bearing upon the health of the employees as affected by the industry. It is found that certain foods act as prophylactics towards certain industrial diseases, and that other foods (perhaps improperly so called) act in the opposite manner. The scientific study of foods in connection with efficient manual labor is a phase of welfare work that has not been considered to the extent it deserves. Take, on the other hand, the horse. It is true that the horse is being

[1] Chairman's address, N. Y. Section—Society of Chemical Industry, October 17, 1913.

displaced by the locomotive and automobile, and as a power factor has been almost completely superseded by mechanical appliances; still, so far as the horse is used for the power he furnishes, his proper feeding is a phase of the application of chemistry to industry. Perhaps, it may be considered that these two illustrations, the feeding of employees and the feeding of horses, are trivial as compared with the study of the production of power through the use of the steam boiler, the steam engine, the gas producer, and the internal combustion engine. Probably this is so, for, in the production of power by these mechanical means, we have clearly recognized chemical reactions, and the understanding of these chemical reactions is essential to the proper economy of fuel and the production of power with the least outlay. In these cases, chemistry teaches us the need of a proper balancing of the combustible material used and the air supply, so that the loss of heat in effluent gases may be reduced to a minimum. In the steam boiler, chemistry has taught much of great value in relation to the refractory materials used, the utility of water consumed, and how to correct its scale-forming tendencies. In recent years, numerous excellent devices have been developed for automatically giving information as to the composition of flue gases, with the result that great savings in the cost of power have been made. The study of the composition of coals has resulted in a better classification of coals, a truer connection between price and quality, and the purchase of coals by specifications involving chemical examination is becoming more extensive each year. The small power plant can not perhaps give as much attention to chemical factors as a large plant can, but in large power plants, the economy resulting from the study of the chemistry of combustion has enabled such plants to furnish power to outsiders with a profit to themselves and to those to whom they sell it. It was chemical considerations that led to the use of blast furnace gases in the gas engine for the production of power; and if the chemist's dream comes true, there will come a time when power will be more directly produced from coal than it is to-day. It is, of course, recognized that in the utilization of the energy in our great waterfalls, chemistry is an unimportant factor, but here there is the compensating fact that many of our great chemical industries have been dependent for their existence and growth upon the cheap power thus produced.

This is as far as our time permits us to speak of the influence of chemistry upon the production of power. The scope of this paper will not allow a more detailed treatment of this subject, and what we have said is more as a matter of obvious illustration of one point of the dependence of the profitableness of industry in general upon chemical factors. If we have made this point clear, we will proceed to recount other phases of the relation of chemistry to industry.

The simplest phase is undoubtedly that which relates to the purely commercial end of industry, wherein goods are bought and sold subject to analysis, the analysis being presumed to indicate the commercial value of the goods. These goods may be in the raw state, partially finished, or finished and ready for consumption. The oldest form of this kind of analytical control was undoubtedly for the valuation of precious metals and the ores containing them. The accuracy with which gold and silver can be determined by fire assay was recognized in the early stages of metallurgical development. The fire assay corresponded on a small scale to the actual

recovery of gold and silver in smelting operations. It was natural, therefore, to assume that a similar correspondence existed between the fire assay of other metalliferous substances and the smelting operations then practised. What could be done with gold and silver, however, could not be done with the same accuracy with the more readily oxidized metals, and while the fire assay method is still applied in some places to metals other than gold and silver, in general these methods have been superseded by wet methods, which are more obviously chemical in their character, and of greater accuracy.

The chemical testing of commodities sold under specifications is primarily for the purpose of protecting the purchaser, although accuracy of testing is necessary in order that justice may be done to the seller. Practically all raw materials dealt in in quantity are sold subject to chemical analysis. Chemical analysis may not be specified in the sale or made use of by the purchaser, but, in some form or other, the purchaser has the right to test out the products received, to see whether the terms of the sale have been lived up to. Very few commodities are sold to-day in regard to which there is not some recorded information on which a purchaser can base claims, if chemical analysis shows these commodities to be different from those described in the order or contract.

If we consider, however, the whole question of the purchase of commodities on either tacit or openly acknowledged chemical requirements, we will see that chemistry has had a great influence in determining the profitableness of industry, in preventing the delivery of inferior raw or semi-raw materials, which would ultimately affect the yield or quality of the finished product. The whole operation of our pure food and pure commodity laws depends upon the availability of chemical analysis and testing, and it is only natural that the rapid growth of sentiment in favor of these laws should have produced some commercial hardships, which have led to the criticism of chemical control and standards as being too rigid and unsuited to popular requirements. Nevertheless, such pure commodity laws have been of great profit to the purchasing public.

But if chemistry has had a great influence upon the profitableness of industry in the purchasing of commodities, what shall we say as to its effect on the profitableness of industry in the sale of commodities? In the popular mind, profits are made on sales, not on purchases, and the salesman seems to be, to use the language of the streets, "the whole thing." Most businesses are dominated by the salesman, be he proprietor, manager, or drummer. According to this idea, in the making of profit, the salesman is a factor greater than the purchasing agent, or even the manager of the manufacturing department, considering that these are distinct from each other. There is undoubtedly a great deal of truth in this conception, and the popular idea rests on fairly well established facts. Taking this to be the case, what has been the influence of chemistry on the sale of commodities as affecting business profits? It is generally admitted that the old-fashioned personal influence of the salesman over the sale of his goods is growing less year by year. In place of this old-fashioned personal influence is coming a newer influence in which the salesman secures his sales, not by debauching the purchaser, but by his intelligence and the helpful knowledge which he possesses about the goods he sells, and, we must add, the confidence which the purchaser has in the salesman because of his possessing that knowledge. It is no longer the general practise to keep sales-

men ignorant of processes of manufacture and use, but salesmen are being educated in many cases by technical men, often chemists, on the merits of their goods and how they may properly meet complaints. Then, too, the chemist's influence in improving the quality of products assists the salesman by giving him more saleable products. I can not take more than passing and regretful notice of the fact that there are some few chemists whose occupation appears to be mostly that of showing how goods may be debased without easy detection. The influence of the chemist in improving the quality of goods shows itself in the increased price which may be obtained for such goods. Perhaps, also, we should mention the general effect upon the commercial atmosphere of a business that has trained chemists in its employ, who give confidence to the general public that its products are made as well as can be with the assistance of the best that science can give.

Coming now to actual manufacturing operations, we will consider what the chemist has done in controlling manufacturing processes, correcting losses in manufacture, assisting in the invention of new methods and in the development of new uses for regular products, waste products and by-products. Work along this line is particularly attractive to the chemist, and, in some cases, can only be conducted profitably by the chemist. The extent to which chemical knowledge is necessary or desirable can, of course, be determined only by considering each case by itself. There are, in every case, practical limitations, in regard to which the chemist should be reasonable. Simply because, in general, chemistry is helpful, it must not, therefore, be assumed that in every case the chemist can increase the profitableness of manufacturing operations, because it must be remembered that the chemist is worthy of his hire, and that hire may more than absorb the value of what he may accomplish. In the control of manufacturing processes, if uniformity of product is desired, there is probably no one better qualified than the chemist to establish such control. This he will accomplish by the systematic study of all the materials entering into the process and the product in all stages of manufacture, discovering the chemical reactions of the process, where these reactions occur, and how they can be accelerated to advantage or made more complete, if that is desirable. Considering in the abstract the manufacturing operation involving a consumption of raw materials, heat, power, and labor, the fundamental units of cost are the time consumed and the quantity of product made. The chemist should possess an analytical mind, and, in the study of a manufacturing process, he will endeavor to develop the effect of these fundamental factors and seek to control the other cost factors, keeping in mind the preservation of the full value of the chemical reactions taking place. Chemistry has been a great help and profit to industry in the control of manufacturing losses, and the business man who fails to recognize its value can not be considered as practical. For the avoidance of such losses, the chemist is peculiarly fitted. Some industries, it is true, can be conducted profitably with large losses of some of the constituents contained in the raw materials, but, in the course of time, these losses must be controlled, for the industry that applies the best control will be the most profitable and the best able to withstand competition. This can be done only by systematic chemical examination of the materials used and by systematic study of the chemical reactions entering into the processes. But the work that chemistry does in preventing losses in manufacture is

not merely the direct prevention of such losses. Chemistry impresses itself sooner or later upon the manufacturer if he is awake, even though he be not technically trained, and he realizes that his manufacturing operations are not shrouded in mystery. The question of yield comes under the law of the conservation of matter. Matter does not disappear without going somewhere, and if it does disappear, it has been stolen, or some mistake has been made in accounting, or the matter has been changed in form, or actually lost in some of the refuse products. This is an exceedingly important subject. Many untechnical men think that yield, as they would express it, is "purely a practical question" and that losses in manufacture, like taxes and death, are something that we can not get away from. The chemist valiantly attacks this belief. He asserts that losses occur for material reasons. This attitude of the chemist is simply a rational attitude which increases very materially the profitableness of industry. In developing new uses for regular products, waste products, and by-products, the chemist has left his indelible mark upon industry. Here he is in the lead, and his constructive mind is not satisfied with announcing his immediate discoveries, but in pointing the way to the rich fields of possible discovery that lie before him.

It is proper here to elaborate a little on the value of chemical societies and their journals. Chemical societies, seeking at all times to bring out the most recent information bearing on chemical problems, obtain numerous papers, which, published in their journals, are available, in most of our large public libraries, to business men whether technically educated or not. Frequently, the information which they may want is obtained in complete form in these journals. In other cases, the information has to be interpreted by chemists, and in still other cases the information is so distantly connected with the problems involved as to be available only to chemists who open up vast possibilities of profit to industry. It is hardly to be expected that the chemist will be acquainted with all the published facts relating to any problem, but if he knows where these facts may be obtained, and if he knows how to interpret them, they soon become available, no matter how long they may have remained buried in the literature of the subject. The application of such facts frequently develops new ones, which in their turn may have high potential value. So valuable are these chemical records that I must not lose this opportunity of pointing to the great service chemists are doing and to urge them to enlarge this service to the greatest practicable degree by further contributions. The knowledge which we may possess is of value to us individually, but in the general service of mankind we can frequently impart some of this knowledge, without hurting ourselves, at the same time extending a helping hand to others.

Much has been written upon the influence of the research chemical laboratory on the profitableness of industry. Valuable information is on record showing how, in numerous cases, the research laboratory has been a tremendous profit to industry. In some cases the research laboratory is devoted almost entirely to the development of new processes and products, and it would appear that the Germans have most successfully applied this method, and that their commercial high standing in chemical manufacture has been more due to this than to any superiority in methods or economies in manufacturing. While this is true, it appears to the writer that the research laboratory has another function not usually recognized. If I were to try to

define this function of the research laboratory in popular language, I would say that it keeps the industry "ahead in the game." It is not only in the concrete things which the research laboratory does that its profitableness is to be measured, but its real value is also in the general advance work that it does. It gives to an industry a proper understanding of the needs of the trade. The industry that does not keep itself informed as to these needs is sure to lag behind. The fundamental information as to the needs of the trade can only be furnished by the chemist who has studied the possibilities, theoretical and practical, of both processes and products. The research laboratory is destroying trade superstitions, which have hindered progress. It has furnished information to salesmen which they have been able to use to practical advantage. It has been in many respects the reflective organ of industry. The research laboratory could not have been any of these things if it were not continuously studying the problem presented directly and indirectly to it and availing itself of the invaluable records preserved in our chemical journals.

In those industries involving the manufacture of chemicals or in which chemistry is a predominating and obvious influence, the chemist is, of course, appreciated, although there are many such industries which do not utilize the chemist as fully and as completely as would be to their advantage. The really successful and profitable chemical manufacturing industries avail themselves of the services of the best chemists obtainable.

The indirect influence of chemistry upon the profitableness of industry should not be overlooked. The philosopher who once said something to the effect that the man who made two blades of grass grow where only one grew before is a public benefactor, stated a truth that applies with a special force to the chemist. The discoveries of chemistry which have been of no direct value to the discoverer, but have been of great indirect value to humanity, are innumerable. Sometimes a chemist is looked upon with scorn because he has not made personal profit out of his discoveries, which he has published to the world and made common property. This form of communism is idealistic. The discoveries of Pasteur have added immense profit to the fermentation industries and have been the saving of innumerable lives. I know of no class which contributes, as chemists do, so freely to the fund of general knowledge on which profitable business is based. Then, too, there is the indirect saving which the chemist is responsible for in the conservation and utilization of industrial products. The studies relating to the corrosion of iron and steel and indeed to all of the phenomena of decay have resulted in greater permanence and durability of the products of industry, the benefits of which all industries may share.

In arguing, as we have, in favor of the proposition that chemistry is a powerful factor in making industry profitable, we must not close our eyes to its limitations. The chemist should be a business man in the best sense of the words, and should recognize that in all successful business operations a proper balancing and coordination of all its factors is necessary. The study of power problems should be made, but the extent to which expenditure for the study of power factors should be made depends upon the importance of the power factor. The testing of materials purchased and used should be made, but the extent to which such testing should be made can only be determined by the proper consideration of its relative importance. New processes and products should be developed, but

there is a limit to expenditure for these ends, which limit is in the hope of profit to be derived. After all, all industry depends upon the production or exchange of articles that are desirable, and the desirability of an article is a determining factor in its value. But not merely must a product be desirable, it must be produced with proper economy, for that is a limiting factor affecting its marketability.

We have discussed this subject in an abstract manner. Many illustrations could have been introduced of how industries have profited through the assistance of chemistry. We have thought it better, however, to omit such illustrations but hope that during the coming year we shall have many papers practically demonstrating that what we have presented in the abstract is concretely true. When we speak of chemistry as affecting the profitableness of industry, we must bear in mind that, while all chemical knowledge may be said to come from the chemist, such knowledge is often made use of with profit by those who are not chemists. This is something that is unavoidable, and it seems to me no attempt should be made to make it avoidable. The benefits which chemists derive from the more general diffusion of chemical knowledge are very much greater than would be the case if chemists were successful in an attempt to make their profession esoteric. The progress of humanity can not be accomplished by making the study of chemistry and the benefits that come from it profitable only to the chemist. It is proper that the chemist should seek to obtain profit from his knowledge and ability, but he can not hope to do this except in some few cases, unless he is willing to give to others at least a portion of the knowledge that he possesses. All industries and occupations are interdependent. All industry depends upon the chemist, and the chemist depends upon all industry. The more this interdependence is recognized, the greater the profit accruing to industry, and the greater the return to the chemist.

G. W. Thompson

International Conference on the Structure of Matter[1]

The first International Conference in Brussels on the Theory of Radiation in 1911 owed its inception to Mr. Ernest Solvay, and proved a great success. Shortly afterwards, Mr. Solvay generously gave the sum of one million francs to form an International Physical Institute (*Nature,* Vol. XC., p. 545), part of the proceeds to be devoted to assistance of researches in physics and chemistry, and part to defray the expenditure of an occasional scientific conference between men of all nations to discuss scientific problems of special interest. In pursuance of this aim the second International Conference or Conseil International de Physique Solvay, was held in Brussels this year on October 27–31, under the able presidency of Professor Lorentz. On this occasion the general subjects of discussion were confined to the structure of the atom, the structure of crystals, and the molecular theory of solid bodies.

Reports were presented by the following: The structure of the atom, Sir J. J. Thomson; Interferenzerscheinungen an Röntgenstrahlen hervorgerufen durch das Raumgitter der Kristalle, Professor Laue; the relation between crystalline structure and chemical constitution, W. Barlow and Professor Pope; some considerations on the structure of crystals, Professor Brillouin, and Molekulartheorie der Festen Korper, Professor Gruneisen.

Among those present at the meeting were Professors Lorentz, Kamerlingh Onnes, Sir J. J. Thomson, Barlow, Pope, Jeans, Bragg, Rutherford, Mme. Curie, Gouy, Brillouin, Langevin, Voigt, Warburg, Nernst, Rubens, Wien, Einstein, Laue, Sommerfeld, Gruneisen, Weiss, Knudsen, Hasenöhrl, Wood, Goldschmidt, Verschaffelt, Lindemann and De Broglie.

[1] From *Nature.*